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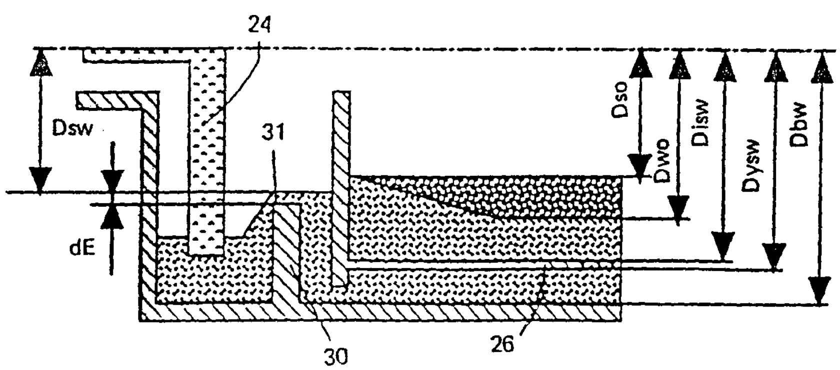

(57) Abstract

A centrifugal separator comprises a drum (1) rotatable about its axis within which annular walls (10, 20) define discharge chambers (11, 21) at the ends of the drum, from which separated fluids of different specific gravities are discharged by respective scoops (14, 24). Alternatively, annular walls (44, 45 and 47, 49) define both such chambers at one end only of the drum. The dimensions of the annular walls are chosen so that the separator is self-regulating, in that the separated fluids are discharged independently of the proportions of the fluids in the incoming mixture, so that operation of the separator does not have to be controlled in response to sensing of the separation process within the drum.

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CENTRIFUGAL SEPARATOR

The invention relates to centrifuges, or centrifugal separators, such as are used separating the components of a mixed fluid stream.

Centrifugal separators typically comprise a vessel with a cylindrical wall which is rotated about its axis. A mixture of fluids of different specific gravities is introduced and concentric annular layers of the individual fluids are formed, with the fluid of greatest specific gravity forming the outermost layer against the cylindrical wall and with the liquid with the least specific gravity forming the layer nearest the axis. The separation effected in this way within the centrifuge has of course to be maintained during extraction of the liquids from it, in spite of varying proportions of the liquid in the incoming mixtures. Operation of the centrifuge can be controlled by a flow control system dependent on the use of sensing devices to detect the positions of the level of the layers or radial interface between them, as described, for example in US Patent 4 846 780. The level or interface sensing means and related control arrangements represent a considerable complication, making a substantial contribution to the complexity and cost of the equipment.

The present invention is accordingly concerned with the provision of a centrifuge or centrifugal separator which is not dependent for its operation on the sensing of the position within it of an interface between adjacent layers of separated liquids.

The invention accordingly provides a centrifuge for separation of liquids of different specific gravities which is dimensioned internally so as to be self-regulating, in that it provides for discharge of the separated liquids regardless of the proportions of the liquids in the incoming

mixture. Discharge from the centrifuge is effected by scoops operating in scoop chambers formed at the respective axial ends of the centrifuge, and in accordance with the invention flows of the liquids from the separated layers within the main volume of the centrifuge is controlled by annular plates or baffles forming weirs which are so dimensioned as to substantially prevent flows from a first layer into the scoop chamber receiving flow from the other layer, even when input to the centrifuge consists substantially entirely of the liquid forming the first layer.

Centrifugal separator devices in accordance with the invention can be employed for example to separate oil from water in an oil extraction system. A well stream may contain gas, oil, water and particulate material, for example, sand. After removal of sand and gas, separation of the oil and water has to be effected to obtain a yield of useful oil thus this can be readily effected by means of the centrifuge of the invention, which is not however limited to this use.

The invention is further described below, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a schematic cross-sectional side view of a typical centrifuge;

Figure 2 is a partial view, on a slightly larger scale, corresponding to the lower left hand part of Figure 1 but showing a centrifuge and modified in accordance with the present invention, and indicating dimensions referred to in the description;

Figure 3 resembles Figure 2 but corresponds to the lower right hand side of Figure 1; and

Figure 4 is a schematic cross-sectional view of a second centrifuge in accordance with the invention.

The centrifuge of Figure 1 comprises a rotatable housing or drum 1 with a cylindrical outer wall 2 and end walls 4 and

5. The drum 1 is mounted so as to be rotatably driven about its axis 6 by any appropriate drive means (not shown). In the Figure, the axis 6 is shown as extending horizontally but the axis can be vertical or have any other desired orientation. A mixture of oil and water, or of other liquids of different specific gravities, is introduced into the drum by a suitable feeder unit (not shown) and the rotation of the drum causes the mixture to separate into concentric layers because of the different specific gravities of the liquids. Thus, an inner annular layer 7 of oil becomes surrounded by an outer annular layer of water 9 confined externally by the cylindrical wall 2 of the drum.

It is of course necessary to arrange for separate extraction from the oil and the water layers, and at a position spaced from the righthand end wall 5, a transverse annular inner wall 10 extends inwardly from the wall 2 to define with the end wall an oil scoop or discharge chamber 11.

Oil enters the chamber 11 from the layer 7 over the inner edge 12 of the annular wall 10 and discharges from the drum 1 by way of an oil scoop 14 within the chamber and an axial discharge pipe 15.

Water is similarly discharged from the lefthand end of the drum 1, from a water scoop or discharge chamber 21, by way of a water scoop 24 and an axially directed discharge pipe 25. The water discharge chamber is again defined by an annular transverse wall, wall 20, spaced from the end wall 4, but the annular wall 20, is spaced inwardly from the drum wall, and a separator sleeve 26, extends axially from its outer edge towards the oil scoop chamber to a position spaced from the wall 10. Water consequently flows axially first towards the oil discharge chamber and it then reverses direction to flow axially into the water scoop chamber.

For a total fluid flow through the centrifuge of 25,000

bbl/d (165m /h), a maximum water flow of 12.500 bbl/d (83m /h), and a maximum oil flow of 18,000 bbl/d (119m /h), suitable operating characteristics and dimensions of the centrifuge can be determined by evaluation of the flow paths, as follows:

Density of crude oil:	p(o) = 870 kg/m
Density of water:	p( ) = 1000 kg/m
Centrifuge rotation speed:	n = 3600 rpm,
	= 377 rad/sec
Diameter of the free surface of	
Inside diameter of the cylindrical wall 2:	457 mm
water in the water scoop chamber 11:	384.5 mm
Outer diameter of the separator sleeve 26:	439 mm
Inner diameter of the separator sleeve 26:	433 mm
Diameter of water/oil interface:	407 mm
Diameter of the free surface of the oil layer 7:	381 mm
Diameter of edge of wall 20 at entry into the water scoop chamber 21:	448 mm

The centrifuge of Figure 1 can thus be designed to operate

satisfactorily, that is, without discharge of any substantial amount of water through pipe 15, or of oil through pipe 25, provided the ratio of oil to water in the incoming mixture does not vary very substantially. To enable the centifuge to operate with incoming mixtures which vary considerably in the ratio of the components, the centrifuge is modified and dimensioned as appears from Figures 2 and 3.

As shown in Figure 2 an additional weir or annular wall 30 extends inwardly from the cylindrical wall 2 between the water scoop 24 and the wall 20, so that its inner edge 31 controls liquid entry into the water scoop chamber.

From the dimensions given above the liquid level, Dsw in

Figure 2, (384.5 mm) in the water scoop chamber is 1.75 mm below the level of the oil layer in the main column of the drum, Dso in Figure 3, (381 mm). If the wall 30 has an internal diameter of 389.5 mm, water at the maximum water flow of 12.500 bbl/d, will pass over the wall into the water scoop chamber 21.

Such an arrangement will be self-regulating provided that the water scoop 24 is able to take out the water that comes into the water discharge chamber with a flow characteristic providing capacity which increases proportionally to the depth of submergence of the scoop and shows no malfunction at different flow rates due for example to gas entering the scoop.

The oil discharge arrangement will be self-regulating with the distance dE shown in Figure 3 equal to 3.25 mm. With the maximum oil inflow (18.00 bbl/d), oil will flow over the edge 12 and into the oil scoop chamber 11.

Suppose first that the centrifuge is operated normally with a crude oil mixture of oil and water which suddenly changes so as to contain substantially no water and to consist substantially only of oil.

The flow of water over the edge 31 of the wall 30 into the water discharge chamber will be reduced until the water level Dsw in the chamber drops to the edge diameter of the wall 30 (389.5 mm). Provided the oil flow is maintained at 18,000 bbl/d the oil level inside the centrifuge will remain constant as this is determined by the diameter of the edge of the wall 10.

As water drains from the centrifuge the water/oil interface increases in diameter. The location of the interface can be found from:

$$p(w)*(Dbw - Dsw) = p(o)*(Dwo - Ds) + p(w)*(Dbw - Dwo)$$

In this equation, and as shown in Figure 2:

Dsw is the diameter of the free surface of water in the water scoop chamber 11,

Dbw is the inside diameter of the cylindrical wall 2,

Dwo is the diameter of the water/oil interface, and

Ds is the free surface diameter of the oil layer 7

With the dimensions given above the result is:

$$Dwo = 442 \text{ mm}$$

The surface of the oil (Ds) is at 381 mm, so that the thickness of the oil layer 7 increases from 13 mm to 30.5 mm and the oil layer enters the return layer of the water. Accordingly to prevent this, the thickness of the wall of the liquid separator sleeve 26 is increased, or the relative thicknesses of the oil and water layers is altered by appropriate selection of Dsw and Dso.

Suppose now that the centrifuge, after operating normally with a mixture of oil and water, suddenly experiences an inflow consisting essentially of water and containing substantially no oil. The flow of oil over the edge 12 of the wall 10 into the oil discharge chamber 11 is reduced to zero and the diameter of the water/oil interface will decrease until a balance is reached with the surface of the water in the water discharge chamber inlet and the edge 12.

Provided the water flow is maintained at 12,500 bl/d, the water level inside the water scoop chamber 21 will remain constant at 384.5 mm. The edge 12 into the oil scoop chamber 11

being at 387.5 mm, is below the water surface diameter. This results firstly in a drainage of oil from the separator, after which water would flow over the edge 12 into the oil

scoop chamber.

In accordance with the invention the thickness of the layers is altered to create a larger height difference between the water surface level in the water scoop chamber and the oil surface level inside the main volume of the centrifuge.

By arranging for the thickness of the oil and water layers to increase from 13 to 25 mm, the diameter of the centrifuge being held constant, the following dimensions are obtained:

Surface diameter (Dso) of the oil layer 7	339 mm
Diameter (Dwo) of the water/oil interface	407 mm
Outer diameter of separator sleeve 26: Dyso =	439 mm
Interior diameter (Dbs) of the drum 2:	457 mm
Diameter (Dsw) of the surface of the water entering the scoop chamber 21	349 mm

The required thickness of the water flowing over the edge 31 into the water scoop chamber is still 2.5 mm, giving an edge diameter of 354 mm.

The thickness of the oil flowing into the oil scoop chamber 11 has to be adjusted from 3.25 mm to 3.5 mm, because the diameter of the surface is reduced and the pressure caused by centrifugal force is lower.

The diameter of the edge 12 at the oil chamber 11 is now 346 mm. With an input of 100% water, the level inside the centrifuge will be lower than the oil edge diameter and there is no longer any risk that water will enter the oil scoop chamber 11. With an input of 100% oil, the water/oil interface diameter (Dwo) will increase to 441.5 mm, allowing a slight oil entry into the water scoop chamber 21 so the diameter of the edge 31 is increased about 1 mm and/or the thickness of the separator sleeve 26 is increased, to prevent

oil from entering the water scoop chamber.

The apparatus illustrated in Figures 1-3 provides for the oil and water discharge pipes 15,25 to be located at opposed ends of the drum 1, but a centrifuge in accordance with the invention can be organised so that both the discharge pipes are at the same end, as shown in Figure 4, in which the reference numerals employed for certain parts of the centrifuge of Figures 1-3 are used to indicate parts with similar functions.

The mixture to be separated is introduced into the drum at an inlet end 39 defined by an axially outwardly convergent frusto conical end wall 40 against which forms the water layer 9 in a thickness which increases in the flow direction towards the cylindrical wall 2 and the outlet end 42 of the centrifuge. The outer layer 9 of oil is similarly formed, with an intermediate layer 41 of the unseparated mixture between it and the layer 7. The thickness of the intermediate layer 41 decreases to zero at the outlet end of the centrifuge, as its components separate out into the oil and water layers.

Adjacent the outlet end 42, the oil scoop chamber 11 is defined by two axially spaced annular walls 44, 45 joined at their outer periphery by a short cylindrical portion 46, spaced from the wall 2. The oil in the layer 7 enters the chamber 11 over the outer edge of the wall 44 and is removed by the oil scoop 14. The water scoop chamber 21 is defined by two further axially spaced annular end walls 47, 49 which extend directly from the cylindrical wall 2. The wall 49 adjacent the outlet end 42 has the same inner diameter as the wall 45 but the diameter of the wall 47 exceeds that of wall 44.

Water from the layer 9 thus enters the water scoop chamber 21 between the wall 2 and the sleeve 46, moving them radially inwardly and over the inner edge of the wall 47, to

be extracted by the water scoop 14.

The centrifuge of Figure 4 thus operates with uni-directional flow of the mixture and of the oil and water layers, without the reversal of axial direction required for the water flow in the centrifuge of Figures 1-3. The centrifige of Figure 4 is of course dimensioned so as to be self-regulating in the same way as the centrifuge of Figure 1-3, and the dimensions noted in Figures 2 and 3 are indicated in Figure 4.

Although the invention has been specifically described with reference to centrifuges for separating oil and water, it is to be understood that the invention could be embodied in centrifuges designed to separate other liquids. The invention can be embodied in a variety of ways other than as specifically described and illustrated.

CLAIMS

1. A centrifuge for separation of first and second fluids of a first and a second, greater, specific gravity, respectively, from a mixture of the fluids, the centrifuge comprising a drum (1) rotatable about the axis (6) thereof to form an annular layer (9) of the second fluid around an annular layer (7) of the first fluid, and first (10,11,14,15) and second (20,21,24,25) means for discharge of the first and second fluids from the respective layers outwardly of the drum, wherein the discharge means regulates the flow of the fluids from the layers so as to effect the separation regardless of the proportions of the fluids in the mixture.

2. A centrifuge as claimed in claim 1 wherein the first and second discharge means comprise respective first and second discharge chambers (11,21) into which the fluids flow from the respective layers over first and second annular weir edges controlling the respective discharge flows.

3. A centrifuge as claimed in claim 2 wherein the first and second discharge chambers (11,21) are defined at respective ends of the drum (1) by respective first and second walls (10,20) providing the weir edges, and wherein a sleeve (26) concentric with the drum axis (6) extends from the second wall towards the first wall to provide a generally axial flow path for the second fluid which reverses direction at the free end of the sleeve, and extends into the second discharge chamber between the second wall and the side wall (2) of the drum (1).

4. A centrifuge as claimed in claim 3 having an annular wall (30) extending inwardly from the drum side wall (2) within the second discharge chamber to a position radially short of the second weir edge.

5. A centrifuge as claimed in claim 2 wherein the first and second discharge chambers (11,21) are defined at one end of the drum (1) respectively by an annular channel inwardly

spaced from the drum side wall (2) and having as its outer wall a wall (44) defining the first weir edge and as its inner wall a second annular wall extending radially inwardly of the weir edge, and by an annular channel comprising walls extending from the drum side wall of which the outer wall (21) defines the second weir edge.

6. A centrifuge as claimed in claim 2, 3, 4 or 5 wherein the discharge means comprise respective scoops (14,24) for extracting fluids from the first and second discharge chambers (11,21) and discharging the fluids axially of the drum.

7. A centrifugal separator comprising:

a drum (1) for receiving a fluid mixture to be separated;

means for rotating the drum (1) about an axis thereof;

baffle means defining two discharge chambers for receiving respective separated fluids from the drum; and

means for drawing off the separated fluids from the respective discharge chambers;

wherein the baffle means comprises an annular wall (10) extending radially into the drum and having an internal diameter predetermined as a function of at least one of the relative specific gravities of the separated fluids, the velocities of the separated fluids and the depth of fluid in the drum,

so that the separator is self-regulating.

8. A centrifugal separator as claimed in claim 7 wherein the internal diameter of the annular wall is predetermined as a function of the Reynolds number for the fluid mixture.

9. A centrifugal separator as claimed in claim 7 or 8 wherein the baffle means comprise a second annular wall extending radially into the drum to define the second discharge chamber for separated fluid.

10. A centrifugal separator as claimed in claim 9 wherein the two discharge chambers are at opposed ends of the drum.

11. A centrifugal separator as claimed in claim 9 wherein the two discharge chambers are at the same end of the drum.

12. A centrifugal separator as claimed in any one of claims 7-11 comprising a separator cylinder arranged with and spaced from and generally parallel with the drum wherein the base of the separator cylinder provides an annular wall at a boundary of one of the annular chambers and the space between the cylinder wall and the drum provides a flow path for one of the separated fluids.

13. A centrifugal separator as claimed in any one of claims 7-12 wherein the internal diameter of the second annular wall is predetermined as a function of at least one of the relative specific gravities of the separated fluids, the velocities of the fluids and the depth of fluid in the separation chamber.

14. A centrifugal separator as claimed in any one of claims 7-13 wherein the means for drawing off fluids comprises a fluid scoop extending into each discharge chamber and connected to axially extending discharge pipes and wherein the position and dimensions of the scoops are predetermined in accordance with the operating parameter of the separator.

15. A centrifugal separator as claimed in any one of claims 7-14 wherein the internal dimensions of the separator are predetermined as a function of the flow paths of the fluids.

16. A centrifugal separator as claimed in any one of claims 7-15 wherein the means for drawing off fluids is adapted to draw off fluid at a rate proportional to the depth of submersion of the scoop in the respective separated fluid.

17. A centrifugal separator as claimed in any one of claims 7-16 wherein the drawing off means is arranged and constructed so as to be independent of different fluid flow rates.

18. A centrifugal separator as claimed in any of claims 7-17 wherein the respective annular walls have dimensions which are chosen to be respectively below the level of the respective fluid by a predetermined distance.

19. A centrifugal separator as claimed in any preceding claim wherein the internal dimensions are chosen so that the separator is self regulating.

20. A process of separating a mixture of fluids by centrifugal action comprising supplying the fluid mixture to an axially rotating drum having at least one annular wall extending radially into the drum to define discharge chambers for respective separated fluids and drawing off separated fluid from each drum at a flow rate dependent upon the internal diameter of the annular wall so that the process is self-regulating.

21. A process as claimed in claim 20 having means for drawing off the separated fluids at a flow rate dependent upon the density of the respective fluids.

22. A process as claimed in claim 20 or 21 wherein the fluids comprise oil and water.

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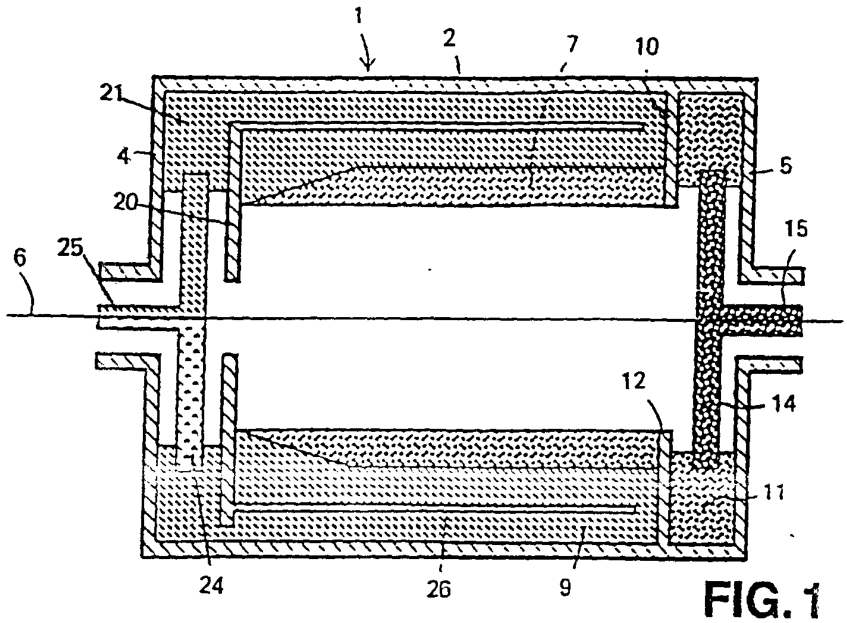

FIG. 1

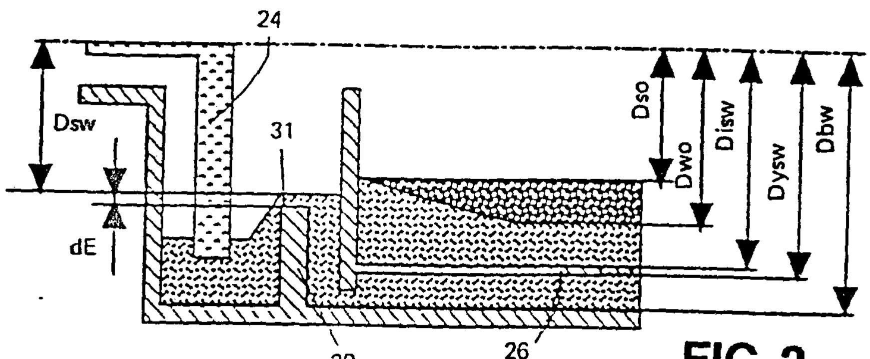

FIG. 2

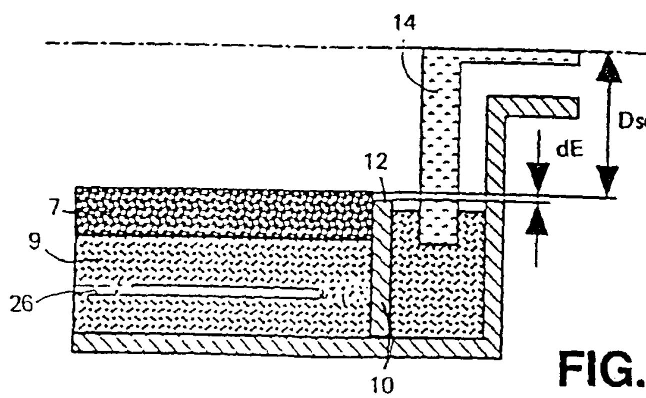

FIG. 3

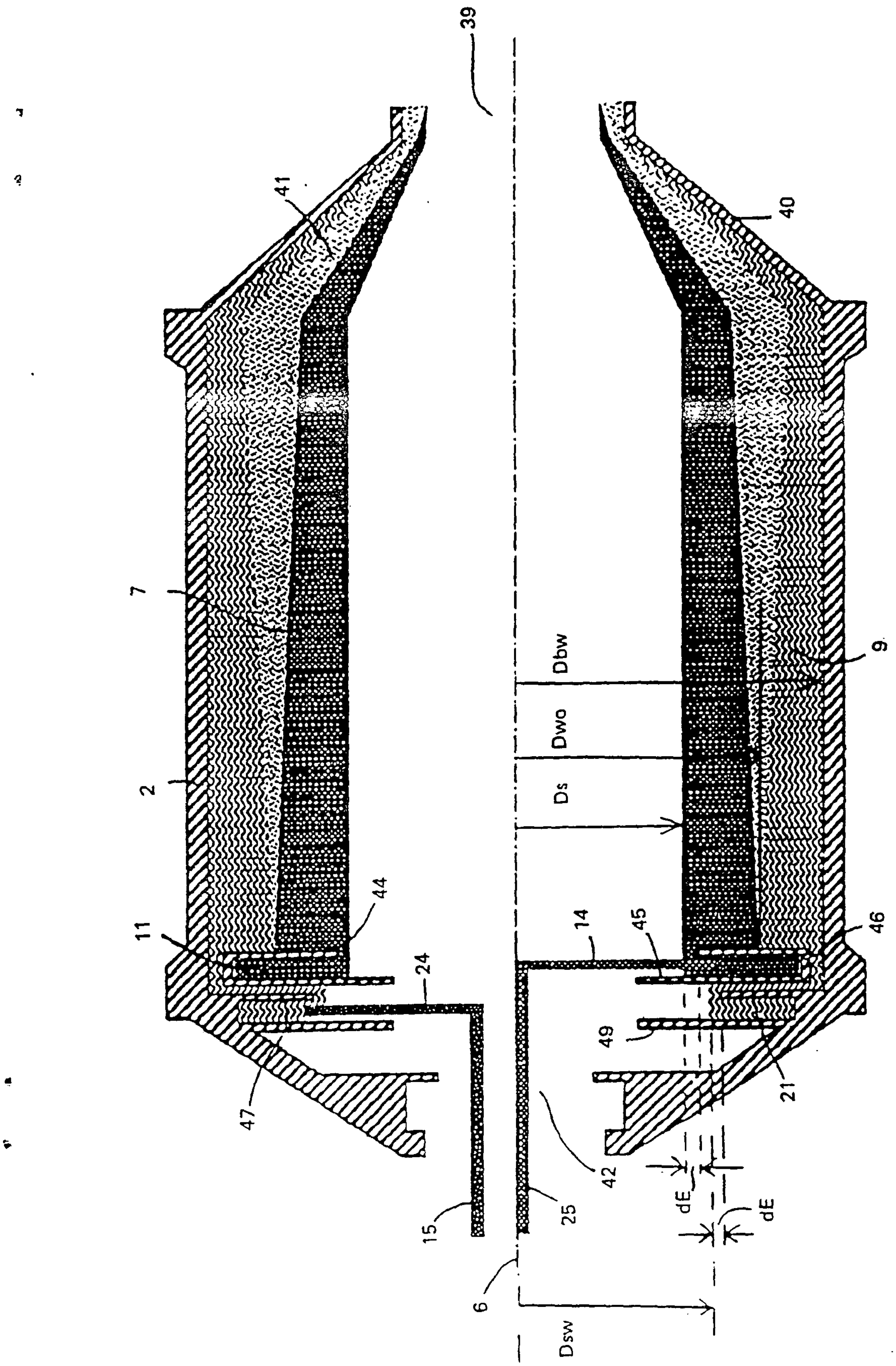

FIG. 4

IN. ...NATIONAL SEARCH REPORT

International Application No PCT/GB 92/02310

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)[6]

According to International Patent Classification (IPC) or to both National Classification and IPC

Int.Cl. 5 B04B1/02; B04B11/02

II. FIELDS SEARCHED

Minimum Documentation Searched[7]

Classification System	Classification Symbols
Int.Cl. 5	B04B

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched[8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT[9]

Category[o]	Citation of Document,[11] with indication, where appropriate, of the relevant passages[12]	Relevant to Claim No.[13]
X	GB,A,260 071 (E.W. GREEN) 18 November 1926	1,2,4,5, 7,9,11, 13,15, 18-20,22
Y	see the whole document	3,6,10
A		8,12,14, 16,17,21
X	EP,A,0 018 474 (R.E. HIGH) 12 November 1980	1,2,7, 17,19, 20,22
Y	see page 2, line 8 - line 13; claims 1-13; figures 1-17	3-6,9, 10,11
A		12-16, 18,21

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IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
22 MARCH 1993	2. 04. 93
International Searching Authority	Signature of Authorized Officer
EUROPEAN PATENT OFFICE	VERDONCK J.C.M.J.

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)		
Category °	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No.
Y	DE,A,2 336 564 (INSTITUT NEORGANITSCHESKOJ CHIMII SIBIRSKOWO OTDELENIJA AKADEMII NAUK.) 3 April 1975 see page 8 - page 16; figures 1-3	3,4,6,9, 10
Y	DE,C,40 702 (J. EVANS & D.H. BURRELL) 3 September 1887 see the whole document	5,6,11

ANNEX TO THE INTERNATIONAL SEARCH REPORT
ON INTERNATIONAL PATENT APPLICATION NO. GB 9202310
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This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report.
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Patent document cited in search report	Publication date	Patent family member(s)		Publication date
GB-A-260071		None		
EP-A-0018474	12-11-80	AU-B-	536744	24-05-84
		AU-A-	5648080	17-09-81
		JP-A-	55142555	07-11-80
		US-A-	4362620	07-12-82
DE-A-2336564	03-04-75	None		
DE-C-40702		None		

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